

AQUEOUS ALTERNATIVES TO **CFC-113** & **MCF** FOR
PRECISION CLEANING OF INERTIAL SYSTEMS & COMPONENTS

Prepared by:

Thomas L. **Ciupak**
Capt. George **Letourneau**
and
Don E. Hunt

Presented by:

Thomas L. **Ciupak**

Mechanical Engineer - Aircraft Product Engineering Branch
Directorate of Maintenance
Aerospace Guidance & Metrology Center (**AGMC**)
Newark Air Force Base, Ohio 43057-5149
United States of America

Commercial Phone: (614) 522-8805
DSN: 346-8805

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BACKGROUND

The Aerospace Guidance and Metrology Center is located in the state of Ohio, U.S.A., at the Newark Air Force Base. It is a repair center in the U.S. Air Force Logistics Command.

The Center has two primary missions. The first is the repair of inertial guidance and navigational systems and components used by most missiles and aircraft in the U.S. Air Force inventory. The inertial systems and components of other Department of Defense agencies and several foreign countries are also repaired at the Center.. The second mission is the management of the U.S. Air Force Single Integrated Metrology and Calibration Program worldwide. The Center repairs thousands of delicate, sophisticated electromechanical devices each year. The critical tolerances of many of the moving parts and other considerations mandate extensive precision cleaning as well as general cleaning during the repair process.

The sophisticated electromechanical devices that form the nucleus of the inertial systems are extremely susceptible to minute contamination. Particles of five microns or less in size can cause a system to fail. As a result, great care must be taken to assure a clean repair environment. Of course, during the repair process it is necessary to carefully clean the parts being assembled.

The Center's industrial processes require extensive use of solvents to meet these cleaning needs. Among the solvents used are CFC-113 and 1, 1, 1-Trichloroethane or Methylchloroform (MCF). CFC-113 is a chloroflourocarbon (1, 1, 2-Trichloro 1, 2, 2-Triflouroethane) .

Historically, the Center has used over two million pounds of CFC-113 annually. Of this amount, over six hundred thousand pounds had to be purchased to replace that which was lost. Not all CFC-113 use is tied into closed-loop reclaimable systems. Therefore, CFC-113 lost to the atmosphere or sent off base as hazardous waste had to be replaced.

CFC-113, in addition to being a hazardous waste, is a serious threat to the atmosphere. Its impact on the ozone layer has generated action to curb its production and use worldwide.

CFC-113 now costs the Center \$2.40 per pound (\$31.44 per gallon). This is 400% of the cost just two years ago (\$0.60 per pound). In addition, the cost of recovery of vapors from the Center's industrial processes, the cost of hazardous waste disposal, and the cost of reprocessing used CFC-113 contribute to the total cost of its use. The cost of using CFC-113, the threat of even higher cost resulting from reduced availability in the future, and the environmental issues have caused the Center to take an aggressive role in finding alternatives for this and other hazardous solvents. For the past three years, Center personnel have been engaged in an intensive

evaluation of equipment, techniques, and processes to identify suitable alternatives for solvent uses.

CONCERNS

The Center's repair processes, as mentioned above, require extensive cleaning. The overwhelming majority of the CFC-113 and MCF used at the Center is used in these cleaning activities.

The Center has done extensive work testing aqueous processes as alternatives for ozone depleting solvents in the critical, or precision, cleaning of metal parts and assemblies of various compositions. The term "precision" cleaning, as used at the Center, encompasses the removal of particles 10 microns or less in diameter, the preparation of surfaces for ensuing processes where the quality of the ensuing process is dependent on the cleanliness of the surface, where the wear between moving parts is a concern, and other special concerns involving "cleanliness." One of the most necessary and critical factors leading to the successful implementation of an alternative to an existing, proven process is the qualification of the alternative. This was, and still is, the case in the Center's efforts to change its cleaning processes to aqueous cleaning to eliminate ozone depleting solvents.

Extensive proof was required at many levels of management that the parts being cleaned were in no way adversely affected, either metallurgically or chemically, by the process and that the resulting cleanliness was at least as good as that obtained using the ozone depleting solvent based processes. Obtaining satisfactory "proof" proved to be difficult. While it was difficult to determine the chemical and metallurgical impact of an alternative process and compare it to the results of the solvent based process, it was possible using the normal methods available in a good physical science laboratory. The determination of the degree of cleanliness, however, was another matter entirely. Currently, a unique method to determine the relative degree of cleanliness is being developed by the Battelle Memorial Institute, Columbus, Ohio - U.S.A. under contract for the Center. This method incorporates the use of stable isotopes to quantify the relative cleaning effectiveness of various cleaning processes and will be discussed later in this paper.

RESULTS

The Center's evaluation of the aqueous process has demonstrated conclusively that with the proper quality of deionized rinse water (15 megohm resistivity nominal - not to fall below 10 megohm), proper water temperature (nominally 155 degrees Fahrenheit), proper filtering of rinse water and detergent solutions (0.2 - 0.5 micron filters),

proper timing of wash and rinse cycles, proper selection of detergent, proper orientation and loading of parts in an ultrasonic cleaning chamber, and properly drying the parts after the cleaning process, no degradation, either chemical or metallurgical, results in either the near or long term. Several ozone depleting solvent based cleaning processes for inertial component parts and assemblies have been Successfully changed to aqueous cleaning at the ^{Center}. The parts and assemblies cleaned with the aqueous process include gimbal rings, float shell halves, fill tubes, and bell covers, and gaskets. In addition, miniature precision instrument bearing assemblies from most of the inertial guidance and navigation systems repaired at the Center are now cleaned using the aqueous process. The various parts consist of copper, jewels, various epoxies and plastics, and alloys of iron, aluminum, and beryllium together with other materials.

Many aqueous cleaning processes are unique. The geometry of a part or assembly, the material it is made of, its sensitivity (i.e. fine coil windings or attachments) , and the type of contamination require that the aqueous cleaning process for that part or assembly be specifically tailored to assure the desired level of cleanliness.

After an aqueous cleaning process has been developed and tailored, it is critical that all parameters verified in the testing phase be adhered. These include water quality, water temperature, detergent concentrations , cleaning and rinsing times, etc.. Failure to do so could result in poor cleaning results, damage to the parts or assemblies, or invalid data for quality control.

In all cases to date, aqueous cleaning processes have proved to be quicker, cleaner, and more cost effective than cleaning processes using CFC-113 and MCF.

CURRENT INITIATIVES

To permit the Center to meet required targets for eliminating ozone depleting and other hazardous solvents, as established by the "Montreal Protocol" international treaty and U.S. Air Force target goals, from its industrial processes, a formal, structured approach was adopted (see Appendix A). The approach provides the necessary guidelines for decision making and also provides streamlining and coordinating the Center's resources to achieve this goal. Under this structured approach, the Center envisions eliminating 90% of the 1990 level of solvent usage by December 31, 1993 - and the remaining 10% by June 1995. Although in its infancy, this structured approach has already gained corporate acceptance and cooperation and many new aqueous cleaning alternative efforts are underway.

As mentioned before, the Center has contracted the Battelle Memorial Institute of Columbus, Ohio to develop, validate, and document, a

stable-isotope-based cleaning performance evaluation method which can be used to quantify the relative cleaning effectiveness of various cleaning processes used to clean items composed of irregular or severe geometries. In order to **assure** reliability and maintainability levels are not degraded when ozone depleting solvents are phased out, a method **is** required to validate that the cleaning capability of **the** suggested alternative is at least as good as that of the existing, proven process. The methods commonly used by the Center to evaluate cleanliness include, but are not limited to, unaided visual examination, microscopic visual examination, solvent filtering with analysis of filter residue, and deionized water break test. However, these methods are not as effective as desired when the item being cleaned is composed of irregular or severe geometries as **is** the case in many of the parts and assemblies composing the precision inertial instruments repaired at the Center. Recent advances in analytical precision, coupled with stable isotope technology, offer a safe and potentially improved approach to measure the cleaning effectiveness. By identifying common contaminants, doping components under test with stable isotopes of these contaminants, **and** then measuring the effectiveness of various cleaning processes to remove these isotopes, a relative measure of cleaning process effectiveness can be established.

CONCLUSION

The Aerospace Guidance and Metrology Center has demonstrated the effectiveness of aqueous based cleaning processes and is continuing to develop other aqueous based cleaning processes with gratifying results. With proper attention to process parameters developed through careful testing and evaluation, the Center has concluded that inertial component parts and assemblies are effectively cleaned, with no resulting degradation, using the aqueous based processes. Also, faster cleaning **times** and better cleaning results are achieved over the traditional solvent based methods.